High-angular resolution observations of the Pistol Star

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Abstract. First results of near-IR adaptive optics (AO)-assisted imaging, interferometry, and spectroscopy of this Luminous Blue Variable (LBV) are presented. They suggest that the Pistol Star is at least double. If the association is physical, it would reinforce questions concerning the importance of multiplicity for the formation and evolution of extremely massive stars.†

Keywords. stars: binaries, stars: circumstellar matter, stars: early-type, stars: mass loss

1. Introducing the Pistol Star

At the time of its formation ∼2 million years ago, the Pistol Star may have been one of the most massive stars in the Milky Way (Figer et al. 1998). Like most other LBV's, it is surrounded by nebulosities, which, therefore, may actually have been ejected by the Pistol Star (cf., e.g., η Car). The shape of the main gas cloud has earned the star its nick name. Owing to its own ejecta but mostly due to its far-away location ($\sim 8\,$kpc) in the region of the Galactic Center, observations of the Pistol Star suffer from very high extinction (20-30 magnitudes in the optical).

Among massive stars, the fraction of binaries may approach 100% at the time of formation (cf. Mason et al. 2009, Sana et al. 2009). In fact, binarity may be one means to enable the formation of massive stars, which with single-star-plus-disk symmetry encounters challenges already at the 10-$M_\odot$ level while observations of LBVs imply original masses that are larger by more than an order of magnitude. One of the most prominent massive stars reported to be a binary is η Car (Damineli, Conti, & Lopez 1997).

2. Observations

In order to more closely examine the nature of the Pistol Star, near-IR observations were undertaken with the VLT AO camera *NACO* and the VLTI spectrograph *AMBER*. The angular resolutions of *NACO*, ranging from natural seeing to near the defraction limit at ∼15 mas, and *AMBER*, 20-3 mas, are perfectly complementary to one other. At a distance of 8 kpc, this permits spatial scales to be studied down to ∼25 AU. The new VLT spectrograph *X-Shooter* provided spectra with $R \sim 5000 - 11000$ over the range 0.3-2.5 μm. They show a vast number of nebular lines; the stellar continuum begins to emerge at $\sim 800\,$nm. At the time of the Symposium, some additional observations were pending, also of other massive stars.

† based on ESO runs 085.D-0182(A), 085.D-0625(A, C)

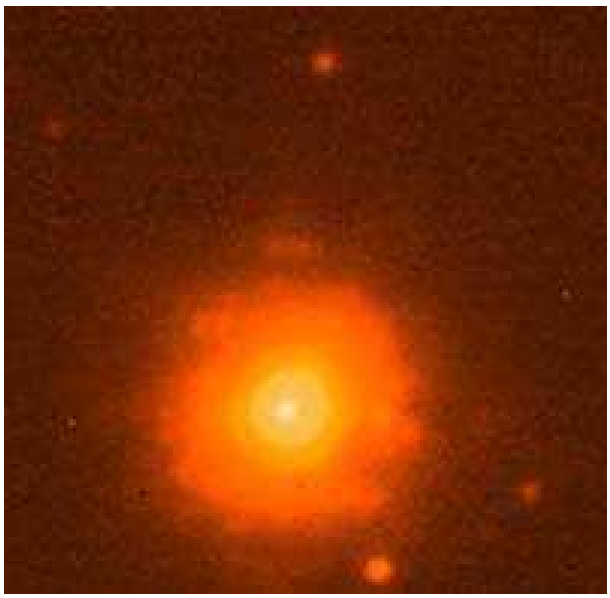

Figure 1. *NACO* image (2.3x2.2 arcsec) of the Pistol Star. Note the appearance of several nearby point sources, while the Pistol Star itself is surrounded by extended nebulosity, measuring roughly 700 AU across. The structure in the nebulosity is not due to discontinuities in the color coding but believed to be real, possibly evidencing multiple shells.

3. First preliminary results

The NACO images resolve most of the stars within 30 arcsec of the Pistol Star into several point sources. Fig. 1 depicts the immediate vicinity of the Pistol Star itself as observed with *NACO* in K band. Apart from several point sources, it reveals an extended nebulosity. At a distance of 8 kpc, its diameter would correspond to more than 6000 AU. Figer et al. 1998 find gas velocities with a range of ∼50-100 km/s but over a larger area. Combining these numbers leads to a crude estimate of the expansion age of 290 years. If the inference from Fig. 1 of multiple shells is correct, they would differ in age by ∼30 years.

A quick preliminary inspection of the *AMBER* interferometry suggests the presence of a further point source at a separation of about 10 mas or ∼80 AU. For comparison: If the 5.5-year period in η Car is orbital, its companion would be at one-fifth or less of this distance. In the *NACO* images, the inner nebulosity looks less structured than in the case of η Car. An effort will be made to continue the observations in order to establish whether the Pistol Star has a physical companion with effects on formation and evolution of the system.

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